



A Retrospective Study on the Effects of Face-to-Face and Online Teaching Methods on Student Performance in Veterinary Anatomy Education

Hasen Awel YUNUS¹  Caner BAKICI^{1,*}  Barış BATUR^{1,2}  Ali Alparslan SAYIM^{2,3}  Aytaç AKÇAY³ 
Çağdaş OTO¹ 

¹ Ankara University, Faculty of Veterinary Medicine, Department of Anatomy, 06070, Ankara, Türkiye

² Ankara University, Graduate School of Health Sciences, 06070, Ankara, Türkiye

³ Ankara University, Faculty of Veterinary Medicine, Department of Biostatistics, 06070, Ankara, Türkiye

Received: 02.10.2025

Accepted: 24.12.2025

ABSTRACT

The Coronavirus Disease 2019 (COVID-19) pandemic triggered a rapid shift from face-to-face to online learning, significantly impacting anatomy education, which relies heavily on practical training. This retrospective study evaluated the effects of face-to-face, online, and hybrid teaching on student performance in Anatomy-I and Anatomy-II courses in Turkish and English veterinary programs at Ankara University from 2017 to 2021. A total of 1.496 students (Turkish: 1.253; English: 243) were included, with academic years categorized as pre-pandemic, acute pandemic, and prolonged pandemic. Performance was analyzed using Chi-square, t-tests, Kappa agreement, and odds ratios. Results showed higher success rates in online Anatomy-II courses, especially in 2020–2021. Anatomy-I outcomes varied, and female students consistently outperformed male students. The hybrid model produced mixed results. Online education, when well-structured, was as effective as traditional methods. Future anatomy education should adopt hybrid models that combine digital flexibility with essential in-person practice.

Keywords: COVID-19 pandemic, Hybrid teaching, Student performance, Veterinary anatomy education.

ÖZ

Veteriner Anatomi Eğitiminde Yüz Yüze ve Çevrimiçi Öğretim Yöntemlerinin Öğrenci Performansına Etkilerinin Retrospektif Bir Çalışması

Koronavirüs hastalığı (COVID-19) salgını, yüz yüze eğitimden çevrimiçi eğitime hızlı bir geçişe neden olmuş ve uygulama eğitimine büyük ölçüde dayanan anatomi eğitimini önemli ölçüde etkilemiştir. Bu retrospektif çalışma, 2017-2021 yılları arasında Ankara Üniversitesi'ndeki Türkçe ve İngilizce veteriner hekimliği programlarında Anatomi-I ve Anatomi-II derslerinde yüz yüze, çevrimiçi ve karma öğretimin öğrenci performansına etkilerini değerlendirmiştir. Toplam 1.496 öğrenci (Türkçe: 1.253; İngilizce: 243) çalışmaya dahil edildi ve akademik yıllar pandemi öncesi, akut pandemi ve uzayan pandemi dönemi olarak kategorize edildi. Performans, Ki-kare, t-testleri, Kappa uyumu ve olasılık oranları kullanılarak analiz edildi. Sonuçlar, özellikle 2020-2021'de çevrimiçi Anatomi-II derslerinde daha yüksek başarı oranları gösterdi. Anatomi-I sonuçları değişiklik gösterdi ve kız öğrenciler erkek öğrencilerden sürekli olarak daha iyi performans gösterdi. Hibrit model karışık sonuçlar verdi. İyi yapılandırılmış çevrimiçi eğitim, geleneksel yöntemler kadar etkiliydi. Gelecekteki anatomi eğitimi, dijital esnekliği temel yüz yüze uygulamalarla birleştiren hibrit modelleri benimsemelidir.

Anahtar Kelimeler: Covid-19 salgını, Hibrit öğretim, Öğrenci performansı, Veteriner anatomi eğitimi.

INTRODUCTION

The Coronavirus Disease 2019 (COVID-19) pandemic has profoundly impacted nations globally, disrupting daily life and challenging established systems across various sectors (Mishrif 2024). One of the most affected fields is education, including medical anatomy education, which has had to adapt rapidly to unprecedented circumstances. Universities and other educational institutions were compelled to transform their traditional education models,

shifting from in-person instruction to distance learning (Longhurst et al. 2020; Darici et al. 2021). This sudden transition exposed significant shortcomings in the preparedness and infrastructure necessary for effective distance education. Traditionally reliant on hands-on, face-to-face instruction, anatomy education was rapidly transitioned to online methods to continue the academic process during these extraordinary circumstances (Bauler et al. 2022).



This shift introduced various new methodologies aimed at supporting and enhancing online learning for students. Anatomy education during the pandemic primarily utilized two forms of distance education: asynchronous and synchronous (Yoo et al. 2021; Chaker et al. 2025). Asynchronous distance education allows students to access learning materials at their own pace through podcasts, recorded lectures, and videos. In contrast, synchronous distance education involves real-time interaction through virtual classrooms and live video conferences (Lu et al. 2011; Sakaue et al. 2024; Jones et al. 2025).

Currently, many medical schools have adopted a blended approach, often referred to as the "flipped classroom" model. In this scenario, students benefit from the advantages of both asynchronous and synchronous learning. They can review materials independently at their convenience and participate in live sessions to deepen their understanding and clarify doubts (Mok 2014; Shi et al. 2018; Veeramani et al. 2015).

In Türkiye, following the government's COVID-19 guidelines, in-person classes were suspended, and education shifted to virtual learning in 2020 to ensure public health safety. The education in Ankara University Faculty of Veterinary Medicine comprises five academic years. Each academic year has two semesters that last 14 weeks. The gross anatomy program integrates theoretical instruction with hands-on practical training and consists of systematic anatomy 1 and systematic anatomy 2 with 3 hours of lecture and 4 hours of practical sessions per week for each lesson in each semester. Systematic Anatomy 1 and 2 are offered in the first and second semesters, respectively. Before COVID-19, theoretical sessions were given face-to-face, and practical sessions were held in the dissection hall in small groups of students under the supervision of a group of anatomy academicians. The final assessment is conducted as an oral examination at the end of each semester and is taken in an oral exam. During the lockdown period, theoretical sessions were conducted online using the electronic learning platform with PowerPoint presentations, and practical lessons were conducted through online videos prepared by academic staff and cadavers and other supplementary educational materials were sent to students via WhatsApp groups. In this period, different online final assessment strategies are used at the end of each semester. One of them was taken in writing for the theoretical part and as a spotter test for the practical part on a university platform. The other one was an online oral assessment same as a face-to-face assessment.

Research during the pandemic has revealed several critical issues, including technological disparities among students and institutions, insufficient training for educators in online teaching methods, and a lack of robust digital platforms for large-scale remote learning (Khaled et al. 2022). The sudden shift from face-to-face education to predominantly online systems posed numerous challenges, such as technical difficulties, limited access to digital resources, and the absence of direct interaction with teachers and peers (Davarpناه et al. 2023; Csorba et al. 2024). This abrupt transition has created significant uncertainty regarding veterinary students' academic outcomes. While some immediate effects are clear, such as technological access disparities and varying levels of engagement, the long-term issues are equally concerning (Goncalves and Capucha 2020; Muca et al. 2022). These include potential declines in academic performance, increased educational inequalities, and adverse impacts on

veterinary students' mental health and motivation. Addressing these concerns is essential to ensure veterinary students receive a quality education and are adequately prepared for future academic and professional endeavors. Understanding and mitigating the challenges of distance learning is imperative to achieve this goal (Bonacini and Murat 2023).

The technique of assessment remains a vital and challenging issue, as highlighted by numerous studies. The sudden transition from face-to-face to online teaching imposed an additional responsibility on educators to evaluate students and ensure they meet specified standards (Devi and Chand 2024). This shift necessitated a reevaluation of assessment methods to maintain the integrity and effectiveness of evaluations, particularly for objective structured practical examinations (OSPE) in anatomy classes (Bhagat et al. 2014; Dissabandara et al. 2023; Sil et al. 2024). Despite the innovative approaches to online and blended learning, there is a significant gap in understanding the effectiveness of these three modalities in assessing student performance in bilingual veterinary anatomy programs (Dooley et al. 2018; Kelly et al. 2021).

We hypothesize that student performance in anatomy courses varies significantly depending on the mode of education, with potential advantages in hybrid or face-to-face models. Therefore, this retrospective study aims to compare student success across online, face-to-face, and hybrid teaching methods by analyzing performance data from anatomy courses in Turkish and English programs. By addressing these critical questions, this study seeks to contribute to the development of robust assessment strategies that uphold academic standards and ensure meaningful evaluations of student competencies.

MATERIAL AND METHODS

Ethics Statement

The required approvals for survey analyses were also obtained from the Ethics Committee of Ankara University of Health Sciences (Approval Number: 2025-07-110).

Study Design

A retrospective study was conducted to evaluate undergraduate students' performance with face-to-face, online and hybrid teaching and assessment methods in Turkish program and English programs during the COVID-19 pre-pandemic (Academic Year (AY) 2017-2018 and AY 2018-2019), the COVID-19 acute pandemic (AY 2019-2020) and the COVID-19 prolonged pandemic (AY 2020-2021) periods in Türkiye. Since Ankara University Faculty of Veterinary Medicine is the only university in Türkiye authorized to offer an English program, only students studying at this university were included in the study (Table 1).

Participants

This study included undergraduate students in Turkish program (n=1253) and English program (n=243) who attended anatomy lessons at the Ankara University Faculty of Veterinary Medicine. Anatomy 1 was given in the first semester of the year and Anatomy 2 was given in the second semester in Ankara University. In consecutive four years (2017-2020), students were exposed to three different teaching and assessment methods. Throughout these years, the same lecturers delivered instruction for Anatomy 1 and Anatomy 2. In the AY 2017-2018 and 2018-2019, students attended lessons face-to-face for the theoretical and practical parts and exams face-to-face oral exam for midterm and final exams. In the AY 2019-2020,

during the first half of the year, students attended lessons face-to-face for the theoretical and practical parts and exams face-to-face oral exam for midterm and final exams, while in the second half of the year, teaching and exams were conducted using the online teaching and assessment method. This AY students faced a hybrid education method. In the AY 2020-2021, all teaching and assessment were conducted through the online method. In this year, students in the English program were assessed via an online oral exam, mirroring the structure of face-to-face assessments. The AY 2019-2020 experienced all periods of anatomy teaching and assessment methods. This class is uniquely placed to compare all style educations and the study took advantage of this opportunity by seeking students' qualitative views on the assessment formats.

Setting

Anatomy is taught during the first year of the five-year program at Ankara University Faculty of Veterinary Medicine. Anatomy 1 covers the locomotor system (bones, joints, and muscles), digestive system, and respiratory system in the first semester, while Anatomy 2 includes the urogenital system, cardiovascular system, endocrine system, nervous system, and sense organs in the second semester. The total anatomy education time is 196 hours (first semester: 42 theoretical, 56 practical; second semester: 42 theoretical, 56 practical). There are no traditional didactic lectures in the practical lessons. Team-based learning in terms of six-seven students study together.

In the AY 2017-2018 and 2018-2019, students attended lessons face-to-face for the theoretical and practical lessons and exams face-to-face oral exam for all exams. In the second year of the AY 2019-2020 and the whole AY 2020-2021 education strategy changed to online education and assessment. The theoretical sessions were conducted online using the electronic learning platform with PowerPoint presentations, and practical lessons were conducted online videos prepared by academic staff of protection cadavers and other supplementary educational materials were sent to students via WhatsApp groups. In this period, different online final assessment strategies are used at the end of each semester for two different programs. In Turkish and English programs, AY 2019-2020 was taken in writing for the theoretical part was taken in answering questions with choosing best answer and open ended questions on traditional atlas pictures on a university platform. Exam questions were negotiated among three anatomy specialists prior to student administration to ensure that memory and application levels were covered in the assessment (Boulos 2022). Anatomy examination consisted of 40 single best answers questions and online assessment time was one hour. There was no negative marking for choosing a wrong answer. Students were permitted to revise and change their answers within the allocated time and before submitting the examination.

Control Variables

Teaching staff consistency: The same lecturers taught both Anatomy 1 and Anatomy 2 throughout the study period (AY 2017-2021), ensuring no confounding variation in instructor expertise or delivery.

Curriculum and Resources

The course content, hours, and team-based learning structure remained unchanged across all years; only the delivery mode (face-to-face vs. online) and assessment methods differed.

Table 1: Education and assessment methods of undergraduate veterinary students studying in Turkish and English programs.

Academic Year	Teaching Methods	Assessment Methods
2017-2018	Face-to-face	Face-to-face
2018-2019	Face-to-face	Face-to-face
2019-2020	Face-to-face (First semester)	Face-to-face (First semester)
	Online (Second semester)	Online (Second semester)
2020-2021	Online	Online *

Assessment Design and Standardization

Face-to-face exams (AY 2017-2019): Oral exams were conducted uniformly by anatomy faculty, with questions drawn from a pre-approved pool to ensure consistency in difficulty and scope. Online exams (AY 2019-2021): Written exams (Turkish/English program, 2019-2020): Questions (40 single-best-answer and open-ended) were validated by three anatomy specialists to cover memory and application levels (Boulos 2022). The 1-hour time limit and lack of negative scoring were standardized. Online oral exams (English program, 2020-2021): Mirrored face-to-face oral assessments in structure and grading rubrics, with faculty trained to administer them virtually under timed conditions

Statistical Analysis

Student performance was compared across pre-pandemic (AY 2017-2019), acute pandemic (AY 2019-2020), and prolonged pandemic (AY 2020-2021) periods, controlling for program language (Turkish/English) and anatomy course (1 vs. 2). These data were used to estimate the impact of face-to-face teaching and assessment, hybrid teaching and assessment, and online teaching and online assessment for two different education programs and student performance according to Anatomy 1 and Anatomy 2 lessons passing grades. Data was analyzed using SPSS version 27.0. Descriptive statistics for the data were calculated and presented as "percentage (n%)" or "mean±standard deviation", based on the distribution of the data. Comparisons of percentages for final, make-up, and passing grades in anatomy courses based on educational models and gender were conducted using Chi-square analysis. The mean passing grades of the courses were compared using the Student's t-test. The agreement between online and F2F (face to face) education for Anatomy-I and Anatomy-II courses was assessed using Kappa analysis. The probability of passing Anatomy-I compared to students who failed Anatomy-II was assessed by calculating the odds ratio (OR). The level of significance was set at $p < 0.05$.

RESULTS

In the Turkish program, Anatomy-I had the highest passing rate in 2020, followed by 2018, with 2017 being the lowest. For Anatomy-II, 2019 had the highest rate, followed by 2020, while 2017 remained the lowest (Figure 1).

In the English program, Anatomy-I had the highest passing rate in 2019, then 2018, with 2017 being the lowest. For Anatomy-II, 2019 also ranked highest, followed by 2020, while 2018 was the lowest (Figure 2).

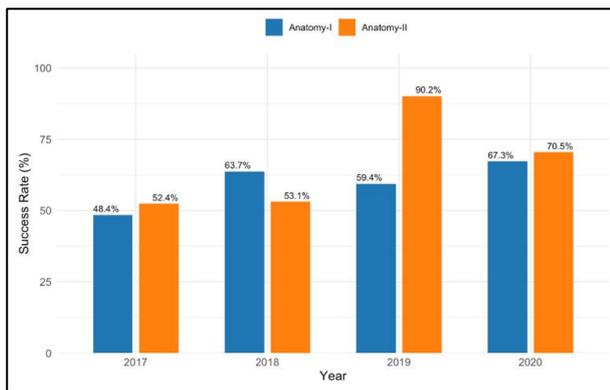


Figure 1: Success percentages by year (Turkish program).

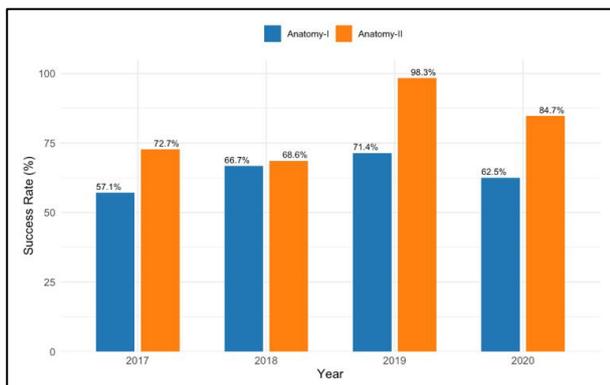


Figure 2: Success percentages by year (English program).

Anatomy-I Turkish Course Success Rates Comparison
Comparison of Anatomy-I Course Success Rates

For the Turkish Program’s Anatomy-I course, no significant difference existed between online and face-to-face models in make-up exams ($p>0.05$), but online final exam and passing rates were significantly higher ($p<0.05$; Table 2). Gender analysis revealed: (1) No gender differences in make-up exams ($p>0.05$), but females outperformed males in final exams and passing rates ($p<0.05$; Table 2); (2) This pattern held for both online (Table 3) and face-to-face courses, where females also scored higher in all assessments ($p<0.05$; Table 4 and Table 5).

Table 2: Comparison of Anatomy-I Course General Education Model Course Passing Status Rates (Turkish program for 2017-2018, 2018-2019, 2019-2020 and 2020-2021 academic years).

General	Education model	Course Passing Status		p
		Failed (n%)	Passed (n%)	
Final	Online	123 (43.8%)	158 (56.2%)	<0.001
	Face to face	544 (55.9%)	429 (44.1%)	
Make-up exam	Online	92 (74.8%)	31 (25.2%)	0.606
	Face to face	418 (77.0%)	125 (23.0%)	
All	Online	92 (32.7%)	189 (67.3%)	0.002
	Face to face	418 (43.0%)	555 (57.0%)	

Table 3: Anatomy-I General Comparison of Course Passing Rates by Gender (Turkish program for 2017-2018, 2018-2019, 2019-2020 and 2020-2021 academic years).

Anatomy-I General	Gender	Course Passing Status		p
		Failed (n%)	Passed (n%)	
Final	Male	412 (58.4%)	294 (41.6%)	<0.001
	Female	255 (46.5%)	293 (53.5%)	
Make-up exam	Male	328 (79.8%)	83 (20.2%)	0.012
	Female	182 (71.4%)	73 (28.6%)	
All	Male	328 (46.5%)	378 (53.5%)	<0.001
	Female	182 (33.2%)	366 (66.8%)	

Table 4: Comparison of Course Passing Rates by Gender in Anatomy-I Online Course (Turkish program from 2019-2020 and 2020-2021 academic year).

Anatomy-I Online	Gender	Course Passing Status		p
		Failed (n%)	Passed (n%)	
Final	Male	82 (53.6%)	71 (46.4%)	<0.001
	Female	41 (32.0%)	87 (68.0%)	
Make-up exam	Male	61 (74.4%)	21 (25.6%)	1.000
	Female	31 (75.6%)	10 (24.4%)	
All	Male	61 (39.9%)	92 (60.1%)	0.005
	Female	31 (24.2%)	97 (75.8%)	

Table 5: Comparison of Course Passing Rates of Anatomy-I Face-to-Face Course by Gender (Turkish program from 2017-2018 and 2018-2019 academic year).

Anatomy-I Face to Face	Gender	Course Passing Status		p
		Failed (n%)	Passed (n%)	
Final	Male	330 (59.7%)	223 (40.3%)	0.007
	Female	214 (51.0%)	206 (49.0%)	
Make-up exam	Male	267 (81.2%)	62 (18.8%)	0.004
	Female	151 (70.6%)	63 (29.4%)	
All	Male	267 (48.3%)	286 (51.7%)	<0.001
	Female	151 (36.0%)	269 (64.0%)	

Anatomy-I English Course Success Rates Comparison

There was no statistically significant difference between online and face-to-face education in the Anatomy-I English program course ($p>0.05$) (Table 6). Similarly, no statistically significant difference was found between females and males in the Anatomy-I English program course ($p>0.05$) (Table 7) or the Anatomy-I English online course ($p>0.05$) (Table 8). Likewise, no significant difference was observed between females and males in the Anatomy-I English face-to-face course ($p>0.05$) (Table 9).

Table 6: Comparison of Anatomy-I English Course General Education Model Course Success Rates (English program for 2017-2018, 2018-2019, 2019-2020 and 2020-2021 academic years).

Anatomy-I General (English program)	Education model	Course Passing Status		P
		Failed (n%)	Passed (n%)	
Final	Online	47 (53.4%)	41 (46.6%)	0.512
	Face to face	76 (49.0%)	79 (51.0%)	
Make-up exam	Online	33 (70.2%)	14 (29.8%)	0.993
	Face to face	52 (68.4%)	24 (31.6%)	
All	Online	33 (37.5%)	55 (62.5%)	0.535
	Face to face	52 (33.5%)	103 (66.5%)	

Table 7: Comparison of Course Success Rates of Anatomy-I English Course According to Gender (English program for 2017-2018, 2018-2019, 2019-2020 and 2020-2021 academic years).

Anatomy-I General (English program)	Gender	Course Passing Status		P
		Failed (n%)	Passed (n%)	
Final	Male	64 (54.2%)	54 (45.8%)	0.273
	Female	59 (47.2%)	66 (52.8%)	
Make-up exam	Male	47 (73.4%)	17 (26.6%)	0.375
	Female	38 (64.4%)	21 (35.6%)	
All	Male	47 (39.8%)	71 (60.2%)	0.123
	Female	38 (30.4%)	87 (69.6%)	

Table 8: Comparison of Course Success Rates by Gender in Anatomy-I English Online Course (English program from 2019-2020 and 2020-2021 academic year).

Anatomy-I Online (English program)	Gender	Course Passing Status		P
		Failed (n%)	Passed (n%)	
Final	Male	23(54.8%)	19(45.2%)	0.977
	Female	24(52.2%)	22(47.8%)	
Make-up exam	Male	17(73.9%)	6(26.1%)	0.823
	Female	16(66.7%)	8(33.3%)	
All	Male	17(40.5%)	25(59.5%)	0.741
	Female	16(34.8%)	30(65.2%)	

Anatomy-II Turkish Course Success Rates Comparison

For Anatomy-II, no difference existed between online and face-to-face models in make-up exams ($p>0.05$), but online students scored higher in final exams and passing rates ($p<0.05$; Table 9 and Table 10). Females consistently outperformed males in online courses ($p<0.05$) (Table 11 and Table 12) and overall course performance (Table 10). However, in face-to-face courses, no gender difference existed in final exams ($p>0.05$), though females scored higher in make-up exams and overall passing ($p<0.05$; Table 13).

Table 9: Comparison of Course Success Rates by Gender in Anatomy-I English Online Course (English program from 2017-2018 and 2018-2019 academic year).

Anatomy-I Face to face (English program)	Gender	Course Passing Status		P
		Failed (n%)	Passed (n%)	
Final	Male	41(53.9%)	35(46.1%)	0.230
	Female	35(44.3%)	44(55.7%)	
Make-up exam	Male	30(73.2%)	11(26.8%)	0.474
	Female	22(62.9%)	13(37.1%)	
All	Male	30(39.5%)	46(60.5%)	0.125
	Female	22(27.8%)	57(72.2%)	

Table 10: Comparison of Anatomy-II Turkish Course General Education Model Course Success Rates (Turkish program for 2017-2018, 2018-2019, 2019-2020 and 2020-2021 academic years).

Anatomy-II General	Education model	Course Passing Status		P
		Failed (n%)	Passed (n%)	
Final	Online	141 (25.3%)	416 (74.7%)	<0.001
	Face to face	445 (60.5%)	291 (39.5%)	
Make-up exam	Online	91 (68.9%)	41 (31.1%)	0.280
	Face to face	348 (78.2%)	97 (21.8%)	
All	Online	102 (18.3%)	455 (81.7%)	<0.001
	Face to face	348 (47.3%)	388 (52.7%)	

Table 11: Anatomy-II General Comparison of Course Success Rates by Gender (Turkish program for 2017-2018, 2018-2019, 2019-2020 and 2020-2021 academic years).

Anatomy-II General	Gender	Course Passing Status		P
		Failed	Passed	
Final	Male	362 (49.7%)	367 (50.3%)	<0.001
	Female	224 (39.7%)	340 (60.3%)	
Make-up exam	Male	286 (81.0%)	67 (19.0%)	<0.001
	Female	153 (68.3%)	71 (31.7%)	
All	Male	296 (40.6%)	433 (59.4%)	<0.001
	Female	154 (27.3%)	410 (72.7%)	

Anatomy-II English Course Success Rates Comparison

Anatomy-II showed no difference between online and face-to-face models for make-up exams ($p>0.05$), but online students scored higher in final exams and passing rates ($p<0.05$; Table 14). No gender differences were found in English program courses, whether overall (Table 15), online (Table 16), or face-to-face (Table 17) (all $p>0.05$).

Table 12: Comparison of Course Success Rates According to Gender in Anatomy-II Online Course (Turkish program from 2019-2020 and 2020-2021 academic year).

Anatomy-II Online	Gender	Course Passing Status		P
		Failed (n%)	Passed (n%)	
Final	Male	97 (32.1%)	205 (67.9%)	<0.001
	Female	44 (17.3%)	211 (82.7%)	
Make-up exam	Male	68 (77.3%)	20 (22.7%)	0.006
	Female	23 (52.3%)	21 (47.7%)	
All	Male	78 (25.8%)	224 (74.2%)	<0.001
	Female	24 (9.4%)	231 (90.6%)	

Table 13: Comparison of Course Success Rates of Anatomy-II Face-to-Face Course by Gender (Turkish program from 2017-2018 and 2018-2019 academic year).

Anatomy-II Face to face	Gender	Course Passing Status		P
		Failed (n%)	Passed (n%)	
Final	Male	265 (62.1%)	162 (37.9%)	0.297
	Female	180 (58.3%)	129 (41.7%)	
Make-up exam	Male	218 (82.3%)	47 (17.7%)	0.012
	Female	130 (72.2%)	50 (27.8%)	
All	Male	218 (51.1%)	209 (48.9%)	0.016
	Female	130 (42.1%)	179 (57.9%)	

Table 14: Comparison of Anatomy-II English Course General Education Model Course Success Rates (English program for 2017-2018, 2018-2019, 2019-2020 and 2020-2021 academic years).

Anatomy-II General (English program)	Education model	Course Passing Status		P
		Failed (n%)	Passed (n%)	
Final	Online	26 (20.0%)	104 (80.0%)	<0.001
	Face to face	48 (50.5%)	47 (49.5%)	
Make-up exam	Online	11 (44.0%)	14 (56.0%)	0.359
	Face to face	28 (58.3%)	20 (41.7%)	
All	Online	12 (9.2%)	118 (90.8%)	<0.001
	Face to face	28 (29.5%)	67 (70.5%)	

The student performance of final, make-up and passing grades in online and face-to-face anatomy courses for both Turkish and English programs (Table 18). The statistical data for final exams, make-up exams, and overall course passing status in Anatomy-I and Anatomy-II. In the Turkish program, face-to-face students performed better in Anatomy-I, while online students had higher scores in Anatomy-II (Figure 3) (Table 18). Significant differences ($p < 0.001$) were observed, particularly in Anatomy-II final exams and course passing rates. However, make-up exam

performance showed less variation between the two modes of education. In the English program, results were mixed. Face-to-face students performed slightly better in Anatomy-I final and make-up exams, but online students had higher scores in Anatomy-II. The difference in Anatomy-II was statistically significant ($p < 0.001$), especially in final exams and course passing status. Overall, online students performed comparably to or slightly better than their face-to-face counterparts in certain cases, suggesting that online education can be effective, particularly in Anatomy-II courses (Table 18).

Table 15: Comparison of Anatomy-II English Course Success Rates by Gender (English program for 2017-2018, 2018-2019, 2019-2020 and 2020-2021 academic years).

Anatomy-II General (English program)	Gender	Course Passing Status		P
		Failed (n%)	Passed (n%)	
Final	Male	35 (33.3%)	70 (66.7%)	0.894
	Female	39 (32.5%)	81 (67.5%)	
Make-up exam	Male	19 (54.3%)	16 (45.7%)	1.000
	Female	20 (52.6%)	18 (47.4%)	
All	Male	19 (18.1%)	86 (81.9%)	1.000
	Female	21 (17.5%)	99 (82.5%)	

Table 16: Comparison of Course Success Rates of Anatomy-II English Online Course by Gender (English program from 2019-2020 and 2020-2021 academic year).

Anatomy-II Online (English program)	Gender	Course Passing Status		P
		Failed (n%)	Passed (n%)	
Final	Male	12 (20.0%)	48 (80.0%)	1.000
	Female	14 (20.0%)	56 (80.0%)	
Make-up exam	Male	4 (33.3%)	8 (66.7%)	0.529
	Female	7 (53.8%)	6 (46.2%)	
All	Male	4 (6.7%)	56 (93.3%)	0.528
	Female	8 (11.4%)	62 (88.6%)	

Table 17: Comparison of Course Success Rates by Gender in Anatomy-I English Online Course (English program from 2017-2018 and 2018-2019 academic year).

Anatomy-II Face to face (English program)	Gender	Course Passing Status		P
		Failed (n%)	Passed (n%)	
Final	Male	23 (51.1%)	22 (48.9%)	1.000
	Female	25 (50.0%)	25 (50.0%)	
Make-up exam	Male	15 (65.2%)	8 (34.8%)	0.526
	Female	13 (52.0%)	12 (48.0%)	
All	Male	15 (33.3%)	30 (66.7%)	0.577
	Female	13 (26.0%)	37 (74.0%)	

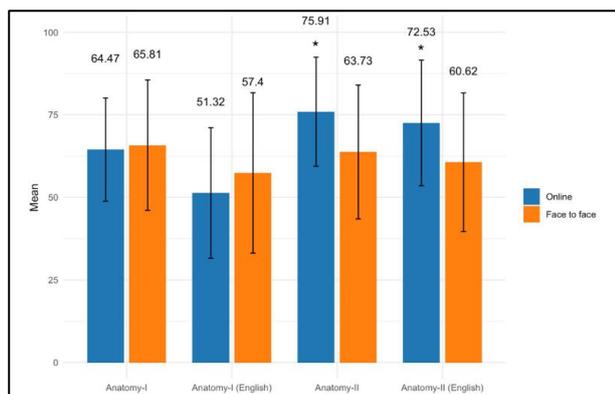


Figure 3: Anatomy Courses Education Model Group Averages Comparison. *: Indicates statistically significant (P<0.05).

Table 18: The student performance in final, make-up and passing grades in online and face-to-face anatomy courses for both Turkish and English programs.

Anatomy	Course Evaluation	Education model	Grade $\bar{x} \pm SD$	p
Anatomy-I (Turkish program)	Final	Online	49.74 ± 19.44	0.001
		Face to face	54.73 ± 22.67	
	Make-up exam	Online	41.57 ± 12.67	0.003
		Face to face	46.69 ± 20.63	
	Course Passing Status	Online	64.47 ± 15.62	0.270
		Face to face	65.81 ± 19.75	
Anatomy-II (Turkish program)	Final	Online	67.18 ± 18.07	<0.001
		Face to face	52.12 ± 22.48	
	Make-up exam	Online	51.46 ± 15.12	0.172
		Face to face	48.35 ± 23.17	
	Course Passing Status	Online	75.91 ± 16.51	<0.001
		Face to face	63.73 ± 20.26	
Anatomy-I General (English program)	Final	Online	51.32 ± 19.77	0.064
		Face to face	56.94 ± 21.39	
	Make-up exam	Online	45.94 ± 13.7	0.089
		Face to face	52.02 ± 17.21	
	Course Passing Status	Online	51.32 ± 19.77	0.069
		Face to face	57.4 ± 24.27	
Anatomy-II General (English program)	Final	Online	68.91 ± 20.98	<0.001
		Face to face	57.4 ± 19.15	
	Make-up exam	Online	58.91 ± 20.17	0.797
		Face to face	57.55 ± 14.71	
	Course Passing Status	Online	72.53 ± 19.02	<0.001
		Face to face	60.62 ± 20.99	

The level of agreement between the Anatomy-I and Anatomy-II courses was assessed using the Kappa test in both face-to-face and online education settings. In face-to-face education, a moderate level of agreement was observed between the two courses (Kappa=0.51). Additionally, students who passed Anatomy-I were 9.63 times more likely to pass Anatomy-II compared to those who did not pass Anatomy-I. In online education, a low level of agreement was found between the Anatomy-I and Anatomy-II courses (Kappa=0.32). Furthermore, students

who succeeded Anatomy-I were 6.25 times more likely to success Anatomy-II than those who did not pass Anatomy-I (Table 19).

Table 19: The level of agreement between the Anatomy-I and Anatomy-II courses was assessed using the Kappa test, both in face-to-face and online education settings.

Course	Education model	Course Passing Status	Course Passing Status	
			Passed (n%)	Failed (n%)
Anatomy-II	Face to Face	Passed	184 (74.5%)	63 (25.5%)
		Failed	67 (23.3%)	221 (76.7%)
	Online	Passed	223 (65.6%)	117 (34.4%)
		Failed	25 (23.4%)	82 (76.6%)

DISCUSSION AND CONCLUSION

This retrospective study provides valuable insights into the comparative effectiveness of online and face-to-face education models in veterinary anatomy courses (Anatomy-I and Anatomy-II) across Turkish and English programs. Higher passing rates were observed in the 2019 and 2020 academic years, whereas the lowest in 2017.

The results indicated that students who took the final examination online achieved significantly higher success rates compared to those who took it in a face-to-face setting. This finding aligns with prior research showing that online assessments may sometimes yield higher success rates, potentially due to reduced exam anxiety, flexible timing, or access to supportive learning materials (Daniel 2020; Gupta et al. 2021). However, it contrasts with studies suggesting face-to-face education facilitates better engagement and deeper understanding, leading to higher performance (Pei and Wu 2019). On the other hand, for make-up exams, no significant difference was observed between online and face-to-face modalities, suggesting that at this stage, students' performance may depend more on individual effort and less on the exam format. When examining overall course outcomes, students in online education demonstrated a higher passing rate compared to face-to-face education. This trend supports findings from emergency remote teaching periods during the COVID-19 pandemic, where online formats unexpectedly yielded higher pass rates, potentially due to assessment flexibility (Adedoyin and Soykan 2023). Comparatively, previous studies focusing on Anatomy education have underscored the challenges posed by online formats due to reduced access to cadaveric material and practical demonstrations (Longhurst et al. 2020). Yet the higher pass rates observed in this study during online education might suggest adaptive success in theoretical parts of Anatomy (Franchi 2020) or it may be due to students taking exams remotely may collaborate (e.g., chat groups, video calls), sharing answers in real-time. Research during the pandemic suggests academic misconduct rates increased during online learning periods. For instance, a study by Lancaster and Cotlarlan (2021) found a sharp rise in online exam cheating compared to traditional in-person exams.

In this study significant gender differences in passing rates was revealed for Turkish veterinary anatomy education program over four academic years of Anatomy-I course (2017-2021). Female students consistently outperformed

male students in both final and make-up exams. The difference in final exam pass rates between female and male students was statistically significant. This is consistent with earlier studies highlighting that female students often exhibit better academic discipline and engagement in courses (Yaman et al., 2023; Kessels and Van Houtte, 2022). During make-up exams, female students demonstrated a significantly higher pass rate compared to male students, reinforcing the trend of better female performance. Overall, the cumulative course passing rate was also significantly higher for females than males. Similar studies have attributed these gender differences to variations in learning strategies, greater academic commitment, and more effective coping mechanisms among female students (Gwazdauskas et al. 2014).

In comparison of Course Passing Rates of Anatomy-I Face-to-Face Course by Gender in Turkish program during 2017-2018 and 2018-2019 academic year, female students had significantly higher pass rates both in final exams and overall course outcomes. These results are in line with prior studies in medical education that have documented female students' superior performance in preclinical and theoretical courses, often attributed to higher academic engagement and better learning strategies (Al-Angari et al. 2022). In a similar pattern gender Differences in Online Anatomy-I Courses in Turkish program during 2019-2020 and 2020-2021 academic year is a statistically significant difference in final exam pass rates. Female students also had a significantly higher overall passing rate. These findings are consistent with earlier studies suggesting that female students may adapt better to online learning environments, demonstrating higher motivation, better time management, and more effective study strategies (Price, 2006; Coldwell et al., 2007). The make-up exam pass rates did not differ significantly by gender during 2019-2020 and 2020-2021 academic year. Our findings support prior research indicating that female students generally perform better in anatomy courses, whether delivered online or face-to-face. For instance, studies have shown that female students tend to engage more in class and utilize more consistent study habits, which may explain their superior outcomes (Kessels and Van Houtte 2022; Yaman et al. 2023).

The current retrospective study evaluated the effects of face-to-face and online teaching methods on student performance in the Anatomy-I English course within veterinary anatomy education. Our findings demonstrated no statistically significant difference in course success rates between the online and face-to-face education models. Additionally, no gender-based difference in academic performance was observed in either mode of instruction. Our results align with previous research showing equivalent learning outcomes between online and face-to-face education in health-related sciences. Studies comparing online and face-to-face learning in medical education found no significant difference in knowledge gains between the two formats (Pei and Wu 2019; Torda and Shulruf 2021). Similarly, Díez-Pascual et al. (2025) also concluded that blended and fully online learning environments often yield comparable or even better outcomes than face-to-face instruction. Online learning led to significantly higher post-test scores and pre-and post-test score gains compared to offline learning. Additionally, online education was more satisfactory to participants than offline learning (Gao et al. 2022). However, contrary to our findings, some studies have noted superior outcomes in face-to-face settings, especially in courses

requiring hands-on practice, such as anatomy. For example, Longhurst et al. (2020) highlighted that students preferred face-to-face anatomy learning, citing better engagement and understanding, particularly for practical components.

The retrospective study examined the effects of online and face-to-face teaching methods on student performance in the Anatomy-II course within the Turkish veterinary anatomy program revealed that students participating in online education achieved significantly higher final exam scores and overall course passing rates compared to those in face-to-face education. No significant difference was found between online and face-to-face students in the make-up exam performance. Moreover, female students outperformed male students in nearly all cases, particularly in the online education setting. Our findings demonstrating better academic outcomes in online anatomy education contrast with some traditional expectations that face-to-face learning, especially for practical courses like anatomy, would yield superior results. The evidence supports that well-structured online learning can be as effective as, or even more effective than, traditional face to face learning in medical education, depending on the instructional design and delivery methods. The transition to online platforms, accelerated by the COVID-19 pandemic, has highlighted the potential for online education to enhance learning outcomes and student satisfaction in medical training (Stevens et al. 2021; Gao et al. 2022).

The retrospective study examined the effects of online and face-to-face teaching methods on student performance in the Anatomy-II course within the English veterinary anatomy program revealed that while there was no statistically significant difference between the online and face-to-face education models for the make-up exam, a significant difference was observed in the final exam and overall course passing rates. Students in the online education model achieved higher final exam scores and course passing rates compared to those in the face-to-face model. This suggests that the online education model may offer certain advantages in terms of student performance, at least in the context of the Anatomy-II course.

The superior performance of students in the online model could be attributed to several factors. Online learning environments often provide greater flexibility, allowing students to learn at their own pace and revisit course materials as needed (Yalcin and Dennen 2024). This flexibility can be particularly beneficial for complex subjects like veterinary anatomy, where students may require additional time to grasp difficult concepts (Stone et al. 2019). Additionally, online platforms often incorporate multimedia resources, interactive tools, and self-assessment modules, which can enhance understanding and retention of anatomical knowledge. These findings align with previous studies that have highlighted the effectiveness of online learning in medical and veterinary education (Pei and Wu 2019; Oliveira et al. 2025). Online learning modules in veterinary education led to improved knowledge retention and student satisfaction compared to traditional lecture-based methods. However, it is important to note that the success of online education may also depend on the specific design and implementation of the course. Not all online courses are created equal, and factors such as the quality of instructional materials, the level of interaction between students and instructors, and the availability of technical support can significantly influence outcomes (Haines et al. 2020; Kelly et al. 2021; Devine et al. 2022). In this study, the online Anatomy-II

course was likely well-structured, with appropriate resources and support systems in place, which may have contributed to the positive results.

In conclusion, this retrospective study demonstrates that online education can be as effective as, and in some cases more effective than, traditional face-to-face methods in veterinary anatomy courses. The higher success rates observed in online learning suggest that when appropriately designed and supported, digital education methods offer a valuable alternative for delivering complex content like anatomy. However, the consistent gender differences, with female students outperforming male students in both formats, highlight the need for further exploration into gender-specific learning strategies. It is important to acknowledge that success in online theoretical assessments may not fully reflect a deep anatomical understanding, particularly regarding the acquisition of hands-on practical skills essential for veterinary practice. While online education shows promise, integrating practical components through blended or hybrid models may help address limitations in hands-on skill acquisition, ensuring comprehensive and equitable anatomy education for veterinary students.

This study has several limitations that should be considered when interpreting the results. The conducted retrospective design introduces potential biases, as we relied on existing academic records rather than controlled experimental data. Variables like student motivation levels, prior knowledge, and pandemic-related stressors could not be standardized or fully accounted for, potentially confounding our results. Also, the result indicated higher pass rates in online courses, which cannot rule out the possibility of academic dishonesty inflating these results. Research shows that online exam cheating increased significantly during pandemic-era remote learning, and our study lacked robust cheating detection methods, like proctoring software or plagiarism checks, that could verify result validity. Lastly, the findings may not generalize beyond Ankara University's specific context, as institutional resources, cultural attitudes toward online learning, and pandemic impacts varied globally. These limitations highlight the need for more systematic, controlled studies to fully understand the comparative effectiveness of different teaching modalities in veterinary anatomy education.

CONFLICTS OF INTEREST

The authors report no conflicts of interest.

ACKNOWLEDGMENT

This study was presented as an oral presentation at the congress named 13th National and 3rd International Veterinary Anatomy Congress and printed as a summary the congress book.

AUTHOR CONTRIBUTIONS

Idea/Concept: HAY, CB, ÇO
 Supervision/Consultancy: AA, ÇO
 Data Collection and/or Processing: HAY, CB, BB
 Analysis and/or Interpretation: AAS, AA
 Writing the Article: HAY, CB, BB, AAS
 Critical Review: ÇO, AA

REFERENCES

- Adedoyin OB, Soykan E (2023).** COVID-19 pandemic and online learning: the challenges and opportunities. *Interact Learn Environ*, 31(2), 863-875.
- Al-Angari NS, Aldaham AS, Masuadi E, Nadeem M, Alkadi L (2022).** The effectiveness of students' performance in preclinical fixed prosthodontics course in predicting subsequent clinical performance. *J Prosthodont*, 31(1), 45-49.
- Bauler LD, Lesciotto KM, Lackey-Cornelison W (2022).** Factors impacting the rapid transition of anatomy curricula to an online environment in response to Covid-19. *Anat Sci Educ*, 15(2), 221-232.
- Bhagat OL, Bhandari B, Mehta B, Sircar S (2014).** Objective structured practical examination and conventional practical examination: a comparison of scores. *Med Sci Educ*, 24, 395-399.
- Bonacini L, Murat M (2023).** Beyond the covid-19 pandemic: remote learning and education inequalities. *Empirica*, 50(1), 207-236.
- Boulos AN (2022).** Evaluation of the effectiveness of online education in anatomy for medical students during the COVID-19 pandemic. *Ann Anat*, 244, 151973.
- Chaker R, Gallot M, Madi A, Collet C, Hoyek N (2025).** Teaching human anatomy before during and after covid-19 pandemic: a longitudinal study on kinesiology students' performance, cognitive load, and congruent embodied learning. *Anat Sci Educ*, 18(1), 48-58.
- Coldwell J, Goold A, Craig A, Mustard J (2007).** Gender and equity in e-learning. *Australas. J Inf Syst*, 15(1), 9-24.
- Csorba LM, Dabija DC (2024).** The impact of the covid-19 pandemic on students' future online education behaviour. *Heliyon*, 10(20), e39560.
- Daniel SJ (2020).** Education and the covid-19 pandemic. *Prospects*, 49(1), 91-96.
- Darici D, Reissner C, Brockhaus J, Missler M (2021).** Implementation of a fully digital histology course in the anatomical teaching curriculum during covid-19 pandemic. *Ann Anat*, 236, 151718.
- Davarpanah SH, Barat Dastjerdi N, Shirzad Z (2023).** Student teachers' experiences of online education during the covid-19 pandemic: challenges and opportunities. *J High Educ Policy Leadersh Stud*, 4(2), 129-135.
- Devi R, Chand SP (2024).** In-service teachers' perceptions and challenges in online assessments amid covid-19. *Int J Assess Eval*, 31(2), 45-56.
- Devine E, Hunt JA, Anderson SL, Mavromatis MV (2022).** Online case-based course in veterinary radiographic interpretation generates better short-and long-term learning outcomes than a virtual lecture-based course. *JVME*, 50(6), 666-676.
- Díez-Pascual AM, García-Díaz P, Peña-Capilla R, Jurado-Sanchez B (2025).** Face-to-face vs. online learning in science and engineering courses during covid-19 epoch. *Res Sci Technol Educ*, 43(1), 347-376.
- Dissabandara LO, Nawaratna S, Nirthanana S (2023).** Fine-tuning the standard setting of objective structured practical examinations in clinical anatomy. *Anat Sci Educ*, 16(3), 486-496.
- Dooley LM, Frankland S, Boller E, Tudor E (2018).** Implementing the flipped classroom in a veterinary pre-clinical science course: Student engagement, performance, and satisfaction. *JVME*, 45(2), 195-203.
- Franchi T (2020).** The impact of the covid-19 pandemic on current anatomy education and future careers: A student's perspective. *Anat Sci Educ*, 13(3), 312-315.
- Gao M, Cui Y, Chen H et al. (2022).** The efficacy and acceptance of online learning vs. offline learning in medical student education: A systematic review and meta-analysis. *JXYM*, 7 (1).
- Goncalves E, Capucha L. (2020).** Student-centered and ict-enabled learning models in veterinarian programs: what changed with covid-19?. *Educ Sci*, 10(11), 343.
- Gupta A, Shrestha RM, Shrestha S, Acharya A, Pandey N (2021).** Impact of e-learning during covid-19 pandemic among medical students in a medical college of nepal: A cross-sectional study. *JNMA*, 59(233), 301-305.
- Gwazdauskas, FC, McGilliard ML, Corl BA (2014).** Characteristics of student success in an undergraduate physiology and anatomy course. *J Dairy Sci*, 97(10), 6378-6381.
- Haines JM, Wardrop KJ, Lindberg CJ et al. (2020).** Development and assessment of a formal learning module to educate veterinary students in an intensive care unit about transfusion reactions. *JVECC*, 30(4), 405-410.
- Jones K, Miller DJ, Noble P (2025).** Did the rapid transition to online learning in response to covid-19 impact students' cognitive load and performance in veterinary anatomy?. *J Vet Med Educ*, 52(1), 70-80.
- Kelly RF, Mihm-Carmichael M, Hammond JA (2021).** Students' engagement in and perceptions of blended learning in a clinical module in a veterinary degree program. *J Vet Med Educ*, 48(2), 181-195.

- Kessels U, Van Houtte, M. (2022).** Side effects of academic engagement? How boys' and girls' well-being is related to their engagement and motivational regulation. *Gen. Educ.*, 34(6), 627-642.
- Khaled A, Hazaymeh WA, Montierre ME (2022).** Challenges of online education for teachers and parents in the emirati school system. *Eur J Educ Res*, 11(4), 2345-2355.
- Lancaster T, Cotarlan C. (2021)** Contract cheating by stem students through a file sharing website: a covid-19 pandemic perspective. *IJEI*, 17 (1), 1-16.
- Longhurst GJ, Stone DM, Dulohery K et al. (2020).** Strength, weakness, opportunity, threat (swot) analysis of the adaptations to anatomical education in the United Kingdom and republic of ireland in response to the covid-19 pandemic. *Anat Sci Educ*, 13(3), 301-311.
- Lu D, Wu Z (2011).** Internet based chinese language distance education system. *Adv Mater Res*, 143, 457-461.
- Mishrif A (2024).** covid-19 effects on the global economy: an overview. *economic effects of the pandemic: implications for the economy, Finance and Tourism*, 3-23.
- Mok HN (2014).** Teaching tip: The flipped classroom. *JISE*, 25 (1), 7 -11.
- Muca E, Cavallini D, Odore R et al. (2022).** Are veterinary students using technologies and online learning resources for didactic training? A mini-meta analysis. *Educ Sci*, 12(8), 573.
- Oliveira D, Soares GSL, Silva Júnior LMD et al. (2025).** Preliminary study on online and in-person teaching methods for animal anatomy. *Cienc Rural*, 55, e20240214.
- Pei L, Wu H (2019).** Does online learning work better than offline learning in undergraduate medical education? A systematic review and meta-analysis. *Med Educ Online*, 24(1), 1666538.
- Price L (2006).** Gender differences and similarities in online courses: challenging stereotypical views of women]. *Comput. Assist. Learn*, 22(5), 349-359.
- Sakaue M, Oishi M, Ozawa A et al. (2024).** Availability and issues of 3D-printed skull models for veterinary anatomy laboratories from students' perspective before and during the covid-19 pandemic. *J Vet Med Sci*, 86(10), 1081-1088.
- Shi CR, Rana J, Burgin S (2018).** Teaching & learning tips 6: the flipped classroom. *Int J Dermatol*, 57(4), 463-466.
- Sil A, Das S, Das P, Jayswal D, Das NK (2024).** Designing, introducing, and implementing objective structured practical examinations as a formative assessment tool in undergraduate medical pharmacology. *Med Educ Dev*, 17(55), 1-9.
- Stevens GJ, Bienz T, Wali N, Condie J, Schismenos S (2021).** Online university education is the new normal: but is face-to-face better?. *ITSE*, 18(3), 278-297.
- Torda A, Shulruf B (2021).** It's what you do, not the way you do it—online versus face-to-face small group teaching in first year medical school. *BMC medical education*, 21, 541.
- Veeramani R, Madhugiri VS, Chand P (2015).** Perception of MBBS students to "flipped classroom" approach in neuroanatomy module. *Anat Cell Biol*, 48(2), 138-143.
- Yalcin Y, Dennen VP (2024).** An investigation of the factors that influence online learners' satisfaction with the learning experience. *EAIT*, 29(4), 3807-3836.
- Yaman R, Hagen KM, Ghaith S, Luong H, Almader-Douglas D, Langley NR. (2023).** Gender bias in medical education: A scoping review. *Clin. Teach*, 20(4), e13592.
- Yoo H, Kim D, Lee YM, Rhyu IJ (2021).** Adaptations in anatomy education during covid-19. *JKMS*, 36(1).